

# Activity 9-3

## Reactions of Hydrocarbons

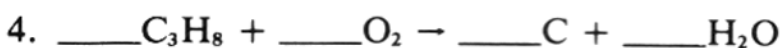
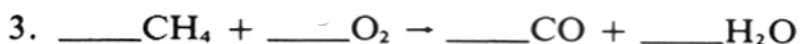
### Combustion

Saturated hydrocarbons react directly with excess oxygen to form carbon dioxide and water. At high temperatures and with a limited supply of oxygen (as in an automobile engine), carbon monoxide and carbon may also be formed.

Write balanced equations for simple combustion (burning) in excess oxygen of each of the following hydrocarbons.



Balance the following equations that show combustion in limited oxygen.



a. Write the balanced equation for the combustion.

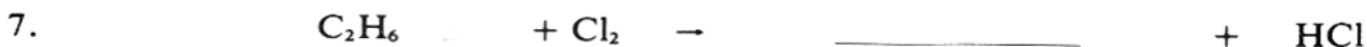
b. What volume (at STP) of  $CO_2(g)$  is produced when 40.0 g  $C_3H_8$  reacts?

c. What mass of  $O_2(g)$  reacts when 15.0 L  $C_3H_8$  measured at STP reacts?

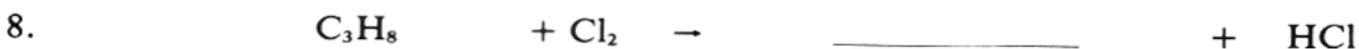
### Substitution

6. What is a saturated hydrocarbon? \_\_\_\_\_

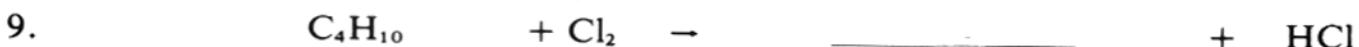
Substitution occurs when one or more hydrogen atoms in a saturated hydrocarbon molecule are replaced by another element or group. Complete the following equations to show the substitution of a single hydrogen atom by a halogen atom.



Names \_\_\_\_\_



Names \_\_\_\_\_



Names \_\_\_\_\_

Halogen derivatives usually exist in several isomeric forms.

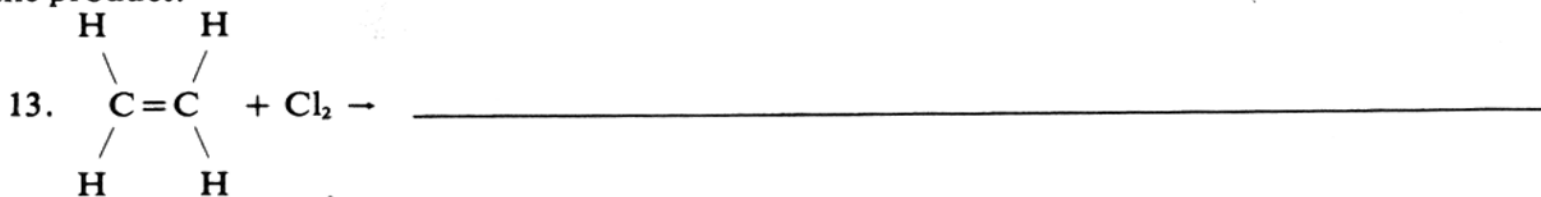
10. Write the structural formulas and the IUPAC names for the four isomers that have the molecular formula  $C_4H_9Cl$ .
11. Write the structural formulas and the IUPAC names for the four isomers that have the molecular formula  $C_3H_6Cl_2$ .

## Addition

12. What is an unsaturated hydrocarbon? \_\_\_\_\_

\_\_\_\_\_

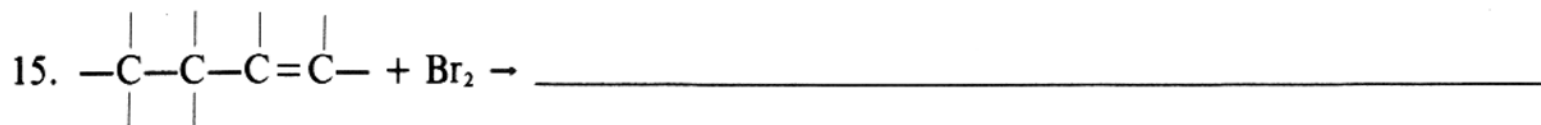
Addition is a reaction that occurs when atoms are added to a molecule at the site of a double or triple bond in an unsaturated compound. Complete the following equations, using structural formulas, to show addition. Write the IUPAC names for the hydrocarbon and for the product.



Names \_\_\_\_\_



Names \_\_\_\_\_



Names \_\_\_\_\_

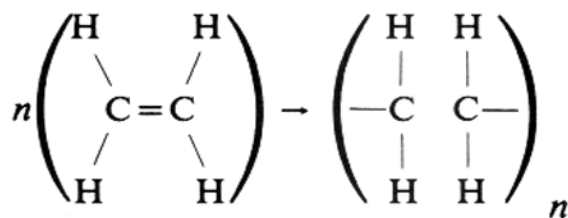
16. What is hydrogenation? \_\_\_\_\_

17. Catalysts are often used for hydrogenation reactions. What is the purpose of these catalysts?

18. Compared to substitution, the reaction rate for addition is \_\_\_\_\_  
(greater/smaller) Account for your answer. \_\_\_\_\_

## Polymerization by addition

19. Addition polymers may be formed when many units called \_\_\_\_\_ are joined together to form a giant molecule. For example, molecules of the unsaturated compound \_\_\_\_\_ with the formula  $C_2H_4$  may be “broken open” to form monomers, as follows:



The above equation shows the fact that  $n$  molecules of \_\_\_\_\_ can be converted to monomers, which then bond together to make a chain \_\_\_\_\_ units long. This chain is a giant molecule or \_\_\_\_\_.

20. What are some addition polymers in everyday use? \_\_\_\_\_

21. Write an equation, using structural formulas, to show the production of polyvinyl chloride, whose formula is  $(\text{CH}_2\text{CHCl})_n$ , from the monomer  $\text{CH}_2=\text{CHCl}$ .

22. Another type of polymer, called a condensation polymer, results from the bonding of monomers by a dehydration reaction, in which water is split off. (See Activity 9-7). What are some condensation polymers in everyday use? \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

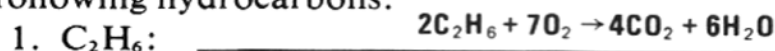
# Activity 9-3

## Reactions of Hydrocarbons

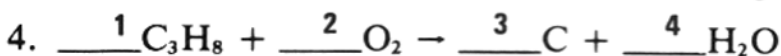
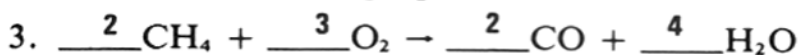
### Combustion

Saturated hydrocarbons react directly with excess oxygen to form carbon dioxide and water. At high temperatures and with a limited supply of oxygen (as in an automobile engine), carbon monoxide and carbon may also be formed.

Write balanced equations for simple combustion (burning) in excess oxygen of each of the following hydrocarbons.

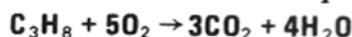


Balance the following equations that show combustion in limited oxygen.



5. Propane ( $\text{C}_3\text{H}_8$ ) burns in excess oxygen to produce  $\text{CO}_2$  and  $\text{H}_2\text{O}$ .

a. Write the balanced equation for the combustion.



b. What volume (at STP) of  $\text{CO}_2(\text{g})$  is produced when 40.0 g  $\text{C}_3\text{H}_8$  reacts?

$$40.0 \text{ g C}_3\text{H}_8 \times \frac{1 \text{ mol C}_3\text{H}_8}{44.0 \text{ g C}_3\text{H}_8} \times \frac{3 \text{ mol CO}_2}{1 \text{ mol C}_3\text{H}_8} \times \frac{22.4 \text{ L}}{1 \text{ mol}} = 61.1 \text{ L CO}_2$$

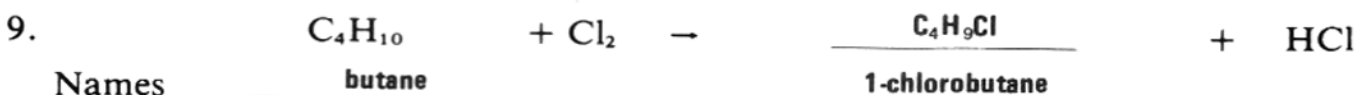
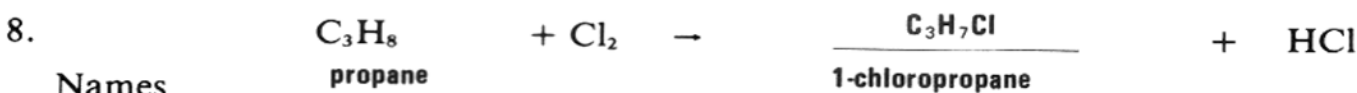
c. What mass of  $\text{O}_2(\text{g})$  reacts when 15.0 L  $\text{C}_3\text{H}_8$  measured at STP reacts?

$$15.0 \text{ L C}_3\text{H}_8 \times \frac{1 \text{ mol C}_3\text{H}_8}{22.4 \text{ L C}_3\text{H}_8} \times \frac{5 \text{ mol O}_2}{1 \text{ mol C}_3\text{H}_8} \times \frac{32.0 \text{ g O}_2}{1 \text{ mol O}_2} = 107 \text{ g O}_2$$

### Substitution

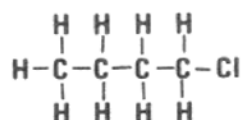
6. What is a saturated hydrocarbon? no multiple bonds exist between carbon atoms; only single bonds exist

Substitution occurs when one or more hydrogen atoms in a saturated hydrocarbon molecule are replaced by another element or group. Complete the following equations to show the substitution of a single hydrogen atom by a halogen atom.

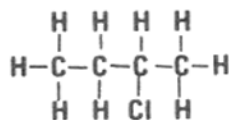


Halogen derivatives usually exist in several isomeric forms.

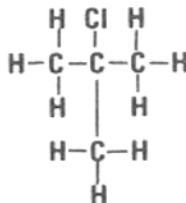
10. Write the structural formulas and the IUPAC names for the four isomers that have the molecular formula  $C_4H_9Cl$ .



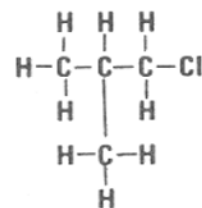
1-chlorobutane



2-chlorobutane

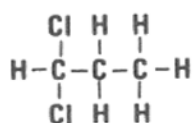


2-chloro-2-methylpropane

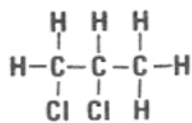


1-chloro-2-methylpropane

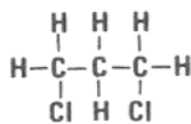
11. Write the structural formulas and the IUPAC names for the four isomers that have the molecular formula  $C_3H_6Cl_2$ .



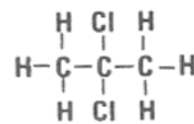
1,1-dichloropropane



1,2-dichloropropane



1,3-dichloropropane

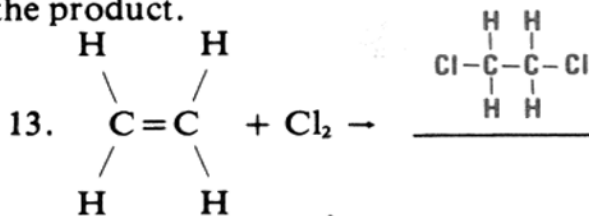


2,2-dichloropropane

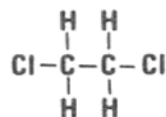
## Addition

12. What is an unsaturated hydrocarbon? a hydrocarbon that contains at least one double or triple bond between adjacent carbon atoms

Addition is a reaction that occurs when atoms are added to a molecule at the site of a double or triple bond in an unsaturated compound. Complete the following equations, using structural formulas, to show addition. Write the IUPAC names for the hydrocarbon and for the product.

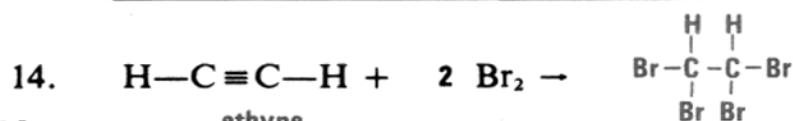


ethene



1,2-dichloroethane

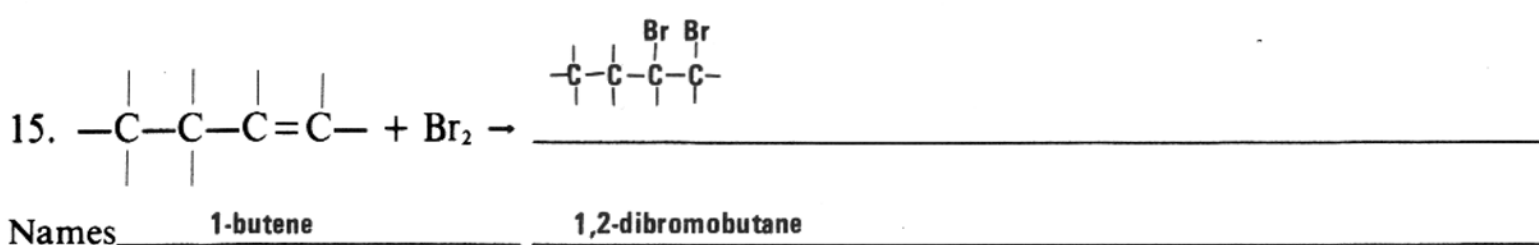
Names \_\_\_\_\_



ethyne

1,1,2,2-tetrabromoethane

Names \_\_\_\_\_



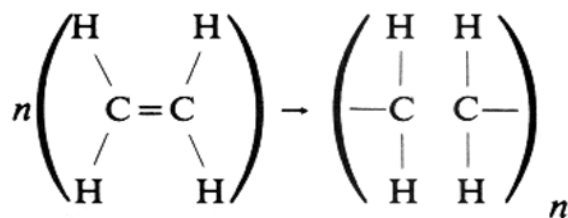
16. What is hydrogenation? an addition reaction in which hydrogen is added to an unsaturated hydrocarbon

17. Catalysts are often used for hydrogenation reactions. What is the purpose of these catalysts?  
to adsorb the hydrogen on the catalysts' surface, thereby increasing the rate of reaction or permitting the reaction to proceed at a lower temperature

18. Compared to substitution, the reaction rate for addition is greater  
 (greater/smaller) Account for your answer. the electrons held in a multiple (double or triple) bond are more easily removed

## Polymerization by addition

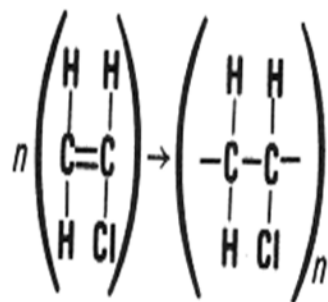
19. Addition polymers may be formed when many units called monomers are joined together to form a giant molecule. For example, molecules of the unsaturated compound ethene with the formula  $C_2H_4$  may be "broken open" to form monomers, as follows:



The above equation shows the fact that  $n$  molecules of ethene can be converted to monomers, which then bond together to make a chain  $n$  units long. This chain is a giant molecule or polymer.

20. What are some addition polymers in everyday use? polyvinylchloride (PVC), teflon, polystyrene, etc.

21. Write an equation, using structural formulas, to show the production of polyvinyl chloride, whose formula is  $(\text{CH}_2\text{CHCl})_n$ , from the monomer  $\text{CH}_2=\text{CHCl}$ .



22. Another type of polymer, called a condensation polymer, results from the bonding of monomers by a dehydration reaction, in which water is split off. (See Activity 9-7). What are some condensation polymers in everyday use? \_\_\_\_\_

nylon, dacron, mylar, bakelite, etc.

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